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X-RAY EMISSION OF FLARES ORIGINATING BEHIND THE SOLAR DISK

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ABSTRACT

Some cases are indicated when sudden ionospheric disturbances (SID) are observed at the moments solar flares are absent on the Sun's disk. — Eighteen such cases were observed during 1959.

It is shown that the observed SID were due to flares occurring behind the limb of the solar disk.

Recordings of the integral intensity of atmospherics in the long-wave band were used as indicators of the SID. Author

* * *

The sudden ionospheric disturbances (SID), conditioned by X-ray emission of solar flares, take place practically simultaneously with the development of flares in the H_α line. — SID are characterized by electron concentration increase in the lower ionosphere and are registered in the form of sudden anomalies in radiowave propagation.

It has been established in [1 - 3] on the basis of observations, that all the flares are not necessarily attended by effects

* [Rentgenovskiye izlucheniya vspyshek voznikayushchikh za limbom solnechnogo diska.]

in the ionosphere; the effectiveness of flare action upon the ionosphere is essentially dependent upon the class of flare. At the same time, the flares occurring at the edge of the solar disk (even on the limb itself), may be accompanied by rather noticeable effects in the ionosphere.

Some works [4 – 6] point out also that in some cases sudden disturbances are observed in the ionosphere at times when there are no flares on the Sun's disk. The explanation of these phenomena is beset with great dufficulties. N. P. Barabashev and I. M. Gordon [5] explain the causes of effect occurrence without flares by the existence in the Sun's disk of the so-called invisible eruptions, which are not attended by the appearance of visible glow, although they are endowed with a significant geoactivity. On the other hand, G. Mastus and M.Wood [6] have revealed, while considering the same question, that nearly of the effects observed by them were linked with manifestations of activity in the H_α line, although they were not attended by flares. Then, it follows from [7], that SID may also be conditioned by flares occurring behind the limb of the solar disk.

As may be seen from the above references, two different viewpoints emerge in the explanation of effects not attended by visible flares in the solar disk. As to which of the proposed hypotheses is most acceptable to explain these effects, is still difficult to say.

The study of the question of SID occurrence at times when no flares are present in the visible part of the Sun may provide informations concerning the generation mechanism of X-ray emission, which, in its turn will constitute an undoubtful interest at investigation of the nature of the flares themselves. Obviously, one of the most important problems is then the determination of the nature of sources of ionizing radiation in the Sun, responsible for these SID.

1.- Registrations of the integral intensity of atmospherics in the 13 – 42 MC band were used as indicators of SID [8, 9]. The behavior of atmospherics during solar flares is characterized by a generally faster increase in their intensity and a relatively slow return to normal level.

[redacted]

All the effects, analogus to solar flares were sorted according to atmospherics' registrations during the year of 1959. About 250 such effects were sorted, the overwhelming majority of which were well identified in time with the respective solar flares. Data on flares were borrowed from [10 - 16], encompassing the results of world observations.

However, for 18 effects in atmospherics, there were no corresponding flares, although according to data from [10, 11 and 13], no observations of the Sun were conducted at these moments. Because of uncertainty stemming from various causes, a series of effects were excluded from consideration.

Let us note that the effects without visible flares in the Sun's disk offer no specific characteristics differentiating them from the effects of usual flares. Nearly 60 percent of the effects considered agree well with the data brought out in [13, 17], and in 15 cases, say 83%, unusual phenomena in Sun's radio emission were observed simultaneously. If there were at these moments, or at least at time of some most powerful effects, any flares in the solar disk, they would have been unquestionably noticed.

Consequently, the manifestation of SID, similar to effects of solar flares, took place in reality at time of absence of flares in the Sun's disk.

2.— If flares were absent in the visible part of the Sun, with SID being observed in spite of it, the assumption of the existence in the Sun's disk of some sources of X-radiation, seemingly distinct from the usual solar flares, becomes natural.

In order to study these sources, the effects, not attended by flares, were compared with the data on rapid processes in the Sun [11, 18]. The results of comparison have shown that in 13 cases fast processes of bright-ejection type at the edge of the disk or of active prominences accompanied the effects in atmospherics in time (with a specific shift). The former were absent in five cases.

To assert reliably that they were really absent in the Sun is difficult. It is interesting to note however, that three cases of absence of unusual phenomena in radio emission correspond precisely to those effects which are not attended by rapid processes.

It was possible to correlate all fast processes with the active groups in the Sun [12], which at these moments were situated either on the limb of the Sun or by 10 to 15 degrees behind it (ascending or descending). The groups' positions were determined approximately on the basis of coordinates of flares occurring in these groups at time of their passing through the disk of the Sun. Most striking is the fact that the coordinates of fast processes are in close correspondence with the coordinates of the identified active groups. This unquestionably points to the fact that all the considered fast processes are definitely linked with the development of these groups and conditioned by them. Nearly all the groups resulted fairly active, and at time of their passing by the disk of the Sun numerous powerful flares occurred in them as a rule.

The development in time of fast processes in some cases either outstrips or falls behind the time of development of these effects, i.e. no detailed correspondence in the development time between these two phenomena is observed. Therefore it cannot be estimated, that the fast processes themselves are directly the sources of X-ray emission responsible for the observed effects.

However, fast processes occur as a rule at time of solar flares. Consequently, the possibility is not excluded that the observed fast processes owe their origin to flares having occurred in these active groups. It is possible to assume on the basis of this, that the considered ionospheric effects are apparently due to solar flares that occurred in the invisible side of the Sun.

As to the effects not accompanied by fast processes, they are just the same identified with the active groups situated, as for the cases with fast processes, either on the limb itself or somewhat behind.

It is evident that in this case also it is most justified to apply the hypothesis of flare occurrence in these groups for the explanation of ionosphere effects.

T A B L E

IONOSPHERE EFFECTS AND PHENOMENA IN THE SUN ATTENDING THEM

(The time is Moscow)

DATA FOR 1959	Effects on the Atmospherics	Sun's radio-emission	FAST PROCESSES			Coordinates of the identified active groups
			comm	end	coord.	
14.I	13^h10^m—13^h48^m	+	12^h45^m—		18N 90W	18N 90W
08.II	12 21 —12 47	+	12 00	—12^h20^m	24N 90E	10N 92E
15.II	14 20 —14 45	+	14 05	—14 14	8N 90E	16N 90E
			14 54	—15 13	21N 90E	
05.III	9 00 —10 00	+	9 15	— 9 28	20N 90W	20N 90W
10.III	8 24 — 9 30	+	9 00	— 9 40	18N 90E	11N 100E
14.III	10 19 —10 30	+	10 39	—11 01 *		
					30N 90W	25N 100W
18.V	7 04 — 7 40	+		—	—	16S 92W
09.VI	19 42 —20 40	+	20 09	—20 22	18N 90E	17N 90E
			20 20	— *	15N 90E	
14.VIII	11 55 —12 40	+	11 10	—13 04 *	39N 90W	5N 90W
15.VIII	9 11 —10 40	+	9 05	— *	7N 90W	5N 100W
			10 06	— *	10S 90W	
19.IX	13 30 —14 05	+	15 04	— *	10S 90W	4N 105W
09.X	11 00 —12 15	—		—	—	10S 95E
09.X	12 40 —13 40	—		—	—	10S 95E
30.X	13 10 —14 10	+	12 35	— *	2N 90W	15S 100W
01.XI	15 30 —15 40	+		—	—	8N 95W
03.XI	10 05 —10 35	+	10 15	—10 41	4S 90W	5N 90W
09.XII	11 34 —12 15	—		—	—	7N 105W
29.XII	12 30 —13 15	+	13 19	—15 30 *	30S 90E	26S 90E

* This denotation indicates active-prominence type processes. In the remaining cases all fast processes — are of the bright-ejection type at the edge of the disk.

The assertion of the possibility of solar flare effect on the ionosphere when these occur behind the limb of the disk agrees well with [7] and is also corroborated by the results obtained in [19]. In this connection it is interesting to point to the event of 20 November 1960 described in [20, 21]. Powerful geophysical effects were observed on that day. The flare responsible for these effects occured in the active group situated behind the solar disk's limb. Its coordinates were respectively determined as 25N, 113W [21]. The manifestation of the flare on the Sun's disk took place as follows: A small hill appeared on the disk at 19 55 h.UT, which began to develop at 20 32 hrs: on reaching a height near $3 \cdot 10^5$ km it disintegrated and went out. Loop-shaped prominences appeared at 21 17 hrs. The ionosphere effect on atmospherics was respectively observed at the following times: commencement at 20 23 h., maximum at 20 41 h., and the end at 21 40 hours.

The authors of reference [21) estimate that the appearance of ionosphere effects is directly due to flare phenomena observed at the disk's limb. However, such assertion is hardly valid, since the comparison of the temporal course of the effect in atmospherics with the development of the observed processes on the disk is beset with great difficulties. It is most likely that the ionosphere effects are also conditioned by the development of the "basic" flare, which would have been behind the limb, while the observed phenomena were only processes attending that flare. That is why the flare of 20 November may serve as a clear proof for the corroboration of the hypothesis on the possibility of action upon the ionosphere of flares occurring behind the limb of the solar disk.

3. — Naturally, the positions of active regions compiled in the Table of the preceding page do not correspond to precise coordinates of the assumed flares, for in the opposite case for limb groups they would have been noticed. All the groups were of great extension and it is thus possible that the flares occurred in those parts which stretched somewhat farther from the visible edge of the disk.

If the flares occurred at a maximum distance of 15° from the edge of the disk, as this follows from the Table, the radial height of the region above the photosphere, which must be observed from the Earth, will be near 20 000 km. A.B.Severnyy and E. F. Shaposhnikova have shown [22], that the region of flare development may spread to several tens of thousand kilometers. Thus the action of translimbal flares on the ionosphere may apparently be explained by a possible egress of X-ray radiation from the flare region through the mass of the upper chromosphere. However, it is not excluded either, that the formation of X-ray radiation of flares may occur simultaneously somewhat above their glow in the line H_{α}.

It is doubtless that the hypothesis of the existence in the disk of the Sun of "invisible" eruptions offers a great interest. However, at present we have no basis to admit it for the explanation of the above-considered effets, while the arguments brought up in [5] are hardly entirely acceptable.

Additional investigations are necessary for a more complete and final solution of this question.

*** THE END ***

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